Standalone Weather Sensors (SAWS)
Human Factors Assessment
Test Plan

Last Revised: September 3, 1999

Federal Aviation Administration
William J. Hughes Technical Center
NAS Human Factors Branch, ACT-530

1. Introduction

The Federal Aviation Administration (FAA) will deploy the Standalone Weather Sensors (SAWS) system at up to 270 Service Level C sites. The SAWS will replace several legacy weather sensors and will provide data about wind speed, wind direction, wind gusts, ambient temperature, dew point temperature, and altimeter setting. The SAWS will serve as a backup system for the existing Automated Surface Observing System (ASOS) and Automated Weather Observing System (AWOS).

The SAWS Program Office (AUA-430) requested human factors expertise from the Air Traffic Requirements Service, Plans and Performance Directorate (ARX-20) to mitigate human factors risks in the selection of a SAWS vendor. ARX-20 and AUA-430 tasked the NAS Human Factors Branch (ACT-530) to support their effort and to provide human factors input to the source selection of SAWS. ACT-530 will conduct a one-week human factors assessment of candidate SAWS systems provided by bidding vendors. Air traffic control personnel from field facilities will serve as assessment participants. Data will be collected using questionnaires and group caucuses. In addition to the assessment results, ACT-530 will compare each candidate system to existing human factors guidelines.

This document describes the detailed procedures that will be followed during this assessment and describes the products that ACT-530 will provide to AUA-430.

2. Method

2.1 Phase 1: Information Gathering

Engineering research psychologists will make three field visits to increase their knowledge of the systems and procedures relevant to SAWS. These visits will be:

1. A one-hour visit to Atlantic City International Airport (ACY) tower and TRACON. The psychologists will learn about current weather sensor equipment and procedures, in particular the ASOS and backup sensors.

2. A 2-hour visit to Millville Automated Flight Service Station. The psychologists will learn about current weather sensor equipment and procedures, especially how these differ from the tower and terminal radar approach control (TRACON) domains.

3. A half-day visit to Northeast Philadelphia Airport (PNE) tower and TRACON. The intent of this visit is to see a wider range of the backup equipment and procedures used in the field.

In each case, psychologists will discuss procedures and equipment with management and other non-bargaining unit employees. The union representatives to the SAWS program from the National Air Traffic Controllers Association (NATCA), Professional Airways Systems Specialists (PASS), and National Association of Air Traffic Specialists (NAATS) will coordinate with the field facilities so they are properly informed about the

purpose of the visits and to encourage voluntary participation from bargaining unit employees. Psychologists will talk with bargaining unit employees on break, if available, on a strictly voluntary basis.

2.2 Phase 2: Human Factors Assessment

2.2.1 Facilities

The assessment will be conducted at the Weather Test Facility (WTF) located on the Otis Air National Guard Base near Falmouth, MA. The tower, TRACON, and AFSS portions of the assessment will be conducted in a large room at the WTF where the SAWS displays will be located. This room will have a large window in one wall to help create the bright illumination condition.

Depending on the technical requirements of the candidate systems, much of the AF portion of the assessment may be conducted in a field adjacent to the WTF where the SAWS instruments will be located. Parts of the AF assessment dealing with documentation and procedures will be conducted inside the WTF.

The assessment requires a conference room capable of seating 20 people with an overhead transparency projector or a computer projector. Arrangements will be made to reserve a suitable room.

2.2.2 Personnel

The assessment will require 15 participants from the field:

1. Five air traffic control (ATC) specialists from different Service Level C facilities. These participants will be drawn from facilities that have both a tower and a TRACON so that the participants can evaluate the candidate systems from both perspectives. ATC specialists who wear sunglasses while working in the tower will be asked to bring their sunglasses to the assessment.

2. Five flight service (FS) specialists from different Service Level C facilities.

3. Five airway facilities (AF) technicians from different Service Level C facilities. These technicians should be navigation and communication technicians with experience maintaining weather sensors similar to SAWS.

Proper coordination with the NATCA, PASS, and NAATS unions will be necessary via ARX-20 and AUA-430.

The assessment will be conducted by engineering research psychologists from ACT-530. A contractor engineering research psychologist from Federal Data Corporation will also provide support during the assessment. Engineering research psychologists from the Office of the Chief Scientific and Technical Advisor for Human Factors (AAR-100) and ARX-20 will provide human factors expertise and coordination to the project. A

contractor technical editor from Federal Data Corporation will provide technical editing and documentation services.

Other technical and management personnel from the FAA may observe the human factors assessment and participate in the caucuses.

2.2.2.1 Non-Disclosure and Conflict-of-Interest

Because this assessment is part of a source selection process, all personnel will be required to sign a non-disclosure form and assert that they have no conflict of interest with any bidding vendor. AUA-430 is responsible for developing and providing these documents to the participants and support personnel.

2.2.3 Equipment

Vendors bidding on the SAWS contract shall provide candidate SAWS hardware and software for the assessment. They shall also provide documentation and any required specialized diagnostic or maintenance equipment. To help prevent bias, participants will not be told the names of the bidding vendors and vendor logos will be covered. SAWS displays will be installed in the WTF. Each candidate system will be separated from the others using room dividers, cube walls, curtains, or other measures. The sensors will be installed in a field adjacent to the WTF on sensor towers.

ACT-530 will provide lamps that, in conjunction with the large window at the WTF, are capable of producing 10,000 fc illumination (the requirement given in the SAWS System Specification). These will be borrowed from the Technical Center television production studio or rented if necessary. Because the lamps are a limited resource, they may affect the number of candidate systems that can be evaluated simultaneously and the assessment schedule. In all cases, psychologists will take ambient and incident illumination measurements to ensure that appropriate lighting levels are achieved.

2.2.3.1 Questionnaires

Two questionnaires (Appendix A) will be used to collect data during the assessment:

1. Background Questionnaire: This questionnaire will collect information about participants' experience, whether or not they use glasses, and other relevant demographic information.

2. System Assessment Questionnaire: This questionnaire will collect participants' judgments about the quality of the SAWS display, the formatting of information, the ease of procedures and so on. This questionnaire uses rating scales and provides room for comments. ATC specialists will complete two questionnaires for each system (dark and bright illumination) whereas FS and AF participants will complete one questionnaire per system. AF participants will use a special version of the questionnaire that deals with issues relevant to maintenance.

2.2.4 ATC and FS Procedure

The assessment will follow the schedule provided in Appendix B.

In the morning of Tuesday, September 28, ACT-530 will brief the ATC and FS participants. Topics will include the goals of the assessment, the procedure, the questionnaires, and procedures for protecting participant confidentiality. The participants will then complete the Background Questionnaire (Appendix A).

ATC participants will then assess the candidate systems in the bright illumination (daytime tower) condition. They will follow the rotation schedule provided in Appendix B. Each participant will evaluate each candidate system one at a time following the procedure script provided in Appendix C and then completing a System Assessment Questionnaire. To mitigate any order effects, participants will evaluate the systems in a counter-balanced order. Participants will rate candidate displays from a distance of 9 ft at three viewing angles: 0, 50, and 75 degrees. Tape marks on the floor will be provided to show participants where to stand. An example is shown in Figure 1.

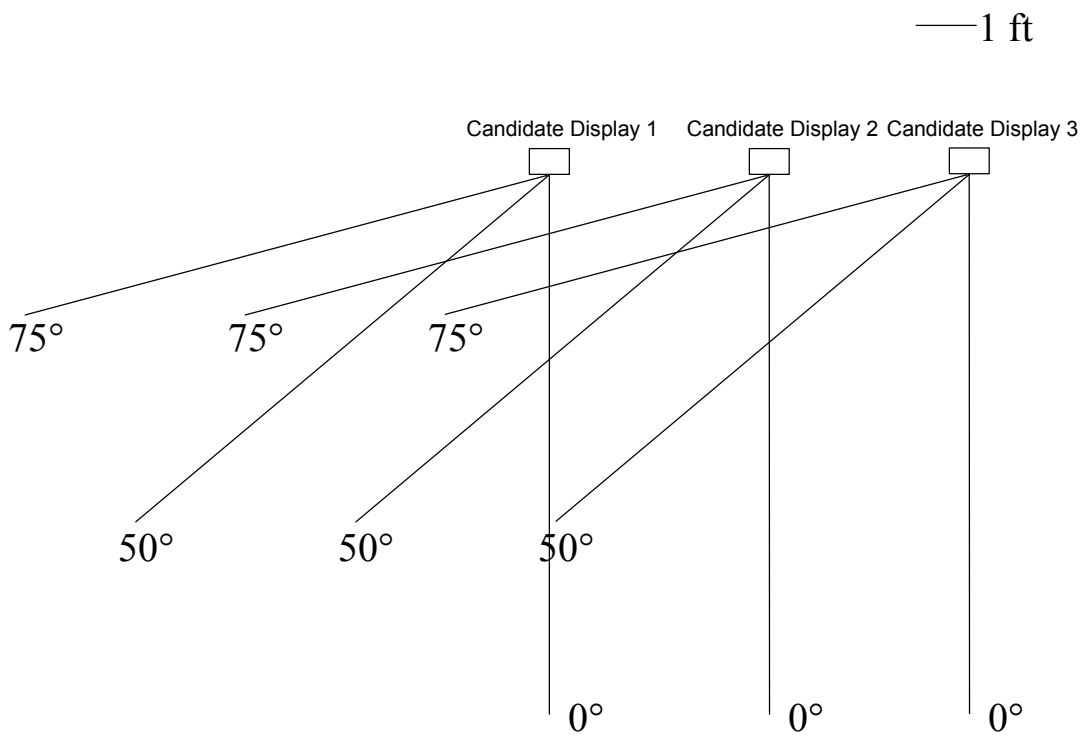


Figure 1. Candidate SAWS displays and viewing angles at which participants will assess displays.

After they have assessed each system individually, the participants will be allowed to re-examine any of the systems. This is to help ensure against presentation-order effects.

Once they are satisfied with their assessments, the psychologists will collect the completed questionnaires.

In the afternoon of September 28, FS participants will complete their assessments in the regular illumination condition. They will follow the same procedure described above. In the evening of September 28, the ATC participants will complete the assessment in the dark illumination (TRACON and nighttime tower) condition. They will follow the same procedure described above.

In the morning of Wednesday, September 29, ACT-530 will lead a group caucus with the ATC and FS participants. The purpose of this caucus is to obtain information about aspects of the systems not covered on the questionnaires and to discuss trends and general findings. The participants will be encouraged to speak openly and honestly about the systems.

2.2.5 AF Procedure

In the morning of Thursday, September 30, ACT-530 will brief the AF participants about the intent of the assessment and the general procedure. The five participants then will evaluate each candidate system as a group using the following procedure for each system.

First, they will receive a 10-minute, high-level briefing about the candidate system from the WTF personnel and AF subject-matter experts who are familiar with the candidate system. This briefing will present an overview of the system architecture and maintenance requirements. It will also discuss diagnostic and calibration procedures and equipment. Second, the participants will briefly review the candidate system documentation. Third, the participants will discuss and interact with the system, to the extent feasible, to simulate the steps and procedures they would need to complete the procedure described in Appendix C. Though many different types of faults could occur, this procedure was selected because it will allow participants to interact with many parts of the candidate system. Fourth, each participant will complete one System Assessment Questionnaire.

Once participants have assessed all candidate systems, ACT-530 will lead a caucus with the AF participants to discuss the systems overall. To supplement the AF assessment, personnel from the WTF will participate in this caucus to provide their insights about the installation of the candidate systems. Topics will include the adequacy of the installation procedures provided by the vendors, adequacy of the documentation and so on.

2.3 Confidentiality and Informed Consent

ACT-530 will deliver this assessment plan to the Technical Center Institutional Review Board (IRB). All research conducted using human participants is subject to review by the IRB. They are responsible for ensuring that adequate anonymity and confidentiality procedures are used and that FAA employees are at minimal risk during their participation. The IRB will have the opportunity to read the assessment plan and provide feedback. The Confidentiality and Informed Consent Statement (Appendix D) will be given to each participant during the opening briefing.

The participants will be treated with the highest degree of professionalism with regard to informed consent and confidentiality. Participants will not write their names on their questionnaires nor will the findings contained in the report be traceable to any individual participant. ACT-530 will not provide raw data to any other organization without the participants' consent. ACT-530 will report only aggregate data (e.g., means, standard deviations) in its reports and briefings.

3. Data Analysis and Reporting

Participant rating data will be analyzed using appropriate statistical techniques and will be reported in the form of means and standard deviations. Appropriate statistical methods (e.g., ANOVAs) will be used to evaluate any differences found between means.

The participants' written comments will be condensed and organized. In past studies, we have found that participants tend to provide the same comment in several different ways. We will edit their responses for clarity and to eliminate redundancy. Once the consolidation has been completed, ACT-530 will provide a draft list of comments to the participants for their review. This is to ensure that no comments were overlooked or edited incorrectly. These data will be provided in the Final Report.

ACT-530 will also evaluate the candidate systems against established human factors guidelines using Appendix E. The guidelines will be: the FAA *Human Factors Design Guide for the Acquisition of Commercial-Off-The-Shelf Subsystems, Non-Developmental Items, and Developmental Items* (Wagner, Birt, Snyder, & Duncanson, 1996), *Human Factors in the Design and Evaluation of Air Traffic Control Systems* (Cardosi & Murphy, 1995), and the *American National Standard for Human Factors Engineering of Visual Display Terminal Workstations* (ANSI, 1988). ACT-530 will provide results of this comparison in the Final report.

ACT-530 will provide three deliverables to AUA-430 in support of this project:

1. ACT-530 will provide a preliminary briefing to AUA-430 on or about October 7. This briefing will present the preliminary findings and recommendations.

2. ACT-530 will deliver a Short Report to AUA-430 on October 15. This report will contain the findings and recommendations in a condensed written form. However, this report will contain neither the comparisons to the human factors guidelines nor the consolidated participant comments.

3. ACT-530 will deliver a Report to AUA-430 on October 29. This report will contain the findings and recommendations in an expanded written form. This report will also contain the comparisons to the human factors guidelines and the consolidated participant comments.

References

American National Standards Institute (ANSI)/Human Factors Society (HFS). (1988). *American national standard for human factors engineering of visual display terminal workstations* (ANSI/HFS 100-1988). Santa Monica CA: Human Factors Society.

Cardosi, K. M., & Murphy, E. D. (1995). *Human factors in the design and evaluation of air traffic control systems* (Technical Report No. DOT/FAA/RD-95/3). Washingtion, DC: Federal Aviation Administration Office of Aviation Research.

Wagner, D., Birt, J. A., Snyder, M. D., & Duncanson, J. P. (1996). *Human factors design guide: For the acquisition of commercial-off-the-shelf subsystems, non-developmental items, and developmental items* (DOT/FAA/CT-96/1). Atlantic City International Airport: Federal Aviation Administration Technical Center.

Appendix A

Assessment Questionnaires

SAWS Human Factors Assessment

PARTICIPANT BACKGROUND QUESTIONNAIRE

Instructions

Please complete the following items below. This background information will be used only to characterize the participants in this assessment as a group. To help us ensure your anonymity, please do not write your name or any other identifying marks on this questionnaire. Please use only your participant code.

---

1. Date: _____
2. Participant Code: _____
3. Number of years experience in your current job: _____
4. Number of years using or maintaining the following weather sensors:

   F-420 anemometer: _____

   HO-83 hygrothermometer: _____

   digital altimeter setting indicator (DASI): _____
5. Number of years experience using or maintaining the ASOS or AWOS: _____
6. Please check all that apply:

   _____ I wear corrective lenses for **distance** while working.

   _____ I wear corrective lenses for **reading** while working.

   _____ I wear **sunglasses** while working.
7. To the best of your knowledge, do you have any color vision problem?

   Yes No

   If Yes, please describe:

SAWS Human Factors Assessment

SYSTEM ASSESSMENT QUESTIONNAIRE: ATC/AFSS

Instructions

Please complete the following items below regarding the candidate SAWS system that you just assessed. To help us ensure your anonymity, please do not write your name or any other identifying marks on this questionnaire. Please use only your participant code.

Please read each item and the rating scales carefully because each question is slightly different.

Date: _____ Participant Code: _____

System Code: A B C D E F G H I J

Illumination Level: Dark Regular Bright

Item	Rating				
1. Rate how easily you could read the **wind speed**.	Extremely Difficult				Extremely Easy
0 degrees	1	2	3	4	5
50 degrees	1	2	3	4	5
75 degrees	1	2	3	4	5
Comments:					
2. Rate how easily you could read the **wind direction**.	Extremely Difficult				Extremely Easy
0 degrees	1	2	3	4	5
50 degrees	1	2	3	4	5
75 degrees	1	2	3	4	5
Comments:					
3. Rate how easily you could read the **wind gust**.	Extremely Difficult				Extremely Easy
0 degrees	1	2	3	4	5
50 degrees	1	2	3	4	5
75 degrees	1	2	3	4	5
Comments:					

Item	Rating				
4. Rate how easily you could read the **ambient temperature**.	Extremely Difficult				Extremely Easy
0 degrees	1	2	3	4	5
50 degrees	1	2	3	4	5
75 degrees	1	2	3	4	5
Comments:					
5. Rate how easily you could read the **dew point temperature**.	Extremely Difficult				Extremely Easy
0 degrees	1	2	3	4	5
50 degrees	1	2	3	4	5
75 degrees	1	2	3	4	5
Comments:					
6. Rate how easily you could read the **altimeter setting**.	Extremely Difficult				Extremely Easy
0 degrees	1	2	3	4	5
50 degrees	1	2	3	4	5
75 degrees	1	2	3	4	5
Comments:					

Item	Rating				
7. Rate how easily you could **distinguish one type of data from another** (e.g., the labels are unambiguous). **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5
8. Rate how easily you could identify the **missing data indicator** ("M"). **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5
9. Rate how easily you could **adjust the display brightness** to an acceptable level (e.g., Did it provide an adequate range? Was the control easy to operate?) **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5
10. Rate how easily you could switch the display **on and off**. **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5

Item	Rating				
11. Rate how likely you are to **inadvertently switch the display off** (e.g., Was the switch located too close to the brightness control?) **Comments:**	Extremely Likely 1	2	3	4	Not at all Likely 5
12. Rate the extent to which the **system status information** distracts from the primary data. **Comments:**	Extremely Distracting 1	2	3	4	Not at all Distracting 5
13. Rate the extent to which the system provides data in a **consistent and familiar** way with the ASOS or AWOS. **Comments:**	Extremely Inconsistent 1	2	3	4	Extremely Consistent 5

SAWS Human Factors Assessment

SYSTEM ASSESSMENT QUESTIONNAIRE: AIRWAY FACILTIES

Instructions

Please complete the following items below regarding the candidate SAWS system that you just assessed. To help us ensure your anonymity, please do not write your name or any other identifying marks on this questionnaire. Please use only your participant code.

Please read each item and the rating scales carefully because each question is slightly different.

Date: _____ Participant Code: _____

System Code: A B C D E F G H I J

Item	Rating				
1. Rate how easy the overall **system architecture** is to understand. **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5
2. Rate the **thoroughness** of the system documentation. **Comments:**	Not at all Thorough 1	2	3	4	Extremely Thorough 5
3. Rate how easy the **system documentation** is to understand and use. **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5
4. Rate how easy the **diagnostic procedures** are to understand and follow. **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5

Item	Rating				
5. If any, rate how easy the **diagnostic tools** are use. **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5
6. Rate how easy it is to determine if this system is **providing accurate data**. **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5
7. Rate how easy it is to determine if there is a **failure of a component** of this system. **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5
8. Rate how easy it is to determine **which component has failed** in this system. **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5

Item	Rating				
9. Rate how easy it is to repair or **replace a failed component** in this system. **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5
10. Rate how easy it is to run **calibration procedures** on this system. **Comments:**	Extremely Difficult 1	2	3	4	Extremely Easy 5

Appendix B

Schedules

Overall Assessment Schedule

Activity	Completed On / To Be Completed By
Visit to ACY tower and TRACON and tower (1 hour)	June 17, 1999
Visit to Millville AFSS (2 hours)	July 31, 1999
Visit to PNE TRACON and tower (1/2 day)	July 31, 1999
Travel to Otis to prepare for assessment (2 days)	July 28, 1999
Development of questionnaires and procedure scripts at Technical Center	August 20, 1998
Delivery of detailed assessment procedure to the SAWS Program Office and Technical Center IRB	August 31, 1999
Final feedback about assessment procedure returned to ACT-530	September 17, 1999
Delivery of final assessment procedure to the SAWS Program Office	September 24, 1999
Assessment (1 week)	October 1, 1999
Preliminary Briefing for AUA-430	October 7, 1999
Delivery of preliminary results to SAWS Program Office	October 15, 1999
Delivery of final results to the SAWS Program Office	October 29, 1999

Daily Schedule

09/26/99:	**Evening**: ACT-530 arrives
09/27/99:	**All Day**: ACT-530 prepares assessment materials and environment
	Afternoon or Evening: Air traffic (AT) and Flight Service (FS) participants arrive
09/28/99:	**Morning**: AT does bright illumination condition (i.e., tower) assessment at WTF
	Afternoon: FS does assessment at WTF
	After Dark: AT does dark illumination conditions (i.e., TRACON) at WTF
9/29/99:	**Morning**: Caucus with AT and FS participants
	Afternoon: ACT-530 does data reduction and analysis
	Afternoon or Evening: Airway Facilities (AF) participants arrive
	Afternoon or Evening: AT and FS participants may depart if they wish
9/30/99:	**Morning**: AT and FS participants depart
	Morning: AF participants do assessment at WTF
	Afternoon: Caucus with AF participants
	Afternoon or Evening: AF participants may depart if they wish
10/01/99:	**Morning**: Catch up, if needed

Rotation Schedule
(This schedule assumes 10 vendors A-J)

Date	Time	ATC 1	ATC 2	ATC 3	ATC 4	ATC 5	FS 6	FS 7	FS 8	FS 9	FS 10
9/28/99	8:30	**Opening Briefing**									
	9:00	A	J	B	I	C	**No Activities Scheduled**				
	9:15	B	I	C	H	D					
	9:30	C	H	D	G	E					
	9:45	D	G	E	F	H					
	10:00	E	F	J	A	I					
	10:15	F	E	A	J	B					
	10:30	**Break**									
	11:00	G	D	F	E	J					
	11:15	H	C	G	D	A					
	11:30	I	B	H	C	F					
	11:45	J	A	I	B	G					
	12:00	**Lunch**									
	13:00	**No Activities Scheduled**					A	J	B	I	C
	13:15						D	G	E	F	H
	13:30						C	H	D	G	E
	13:45						B	I	C	H	D
	14:00						H	C	G	D	A

Date	Time	ATC 1	ATC 2	ATC 3	ATC 4	ATC 5	FS 6	FS 7	FS 8	FS 9	FS 10
9/28/99	14:15						J	A	I	B	G
	14:30						**Break**				
	15:00						G	D	F	E	J
	15:15						E	F	J	A	I
	15:30						I	B	H	C	F
	15:45						F	E	A	J	B
	16:00						**No Activities Scheduled**				
	19:30	F	E	A	J	B					
	19:45	B	I	C	H	D					
	20:00	I	B	H	C	F					
	20:15	H	C	G	D	A					
	20:30	E	F	J	A	I					
	20:45	A	J	B	I	C					
	21:00	**Break**									
	21:30	G	D	F	E	J					
	21:45	D	G	E	F	H					
	22:00	C	H	D	G	E					
	22:15	J	A	I	B	G					
	22:30	**End**									

Date	Time	ATC 1	ATC 2	ATC 3	ATC 4	ATC 5	FS 6	FS 7	FS 8	FS 9	FS 10
09/29/99	8:30	**Caucus**									
	10:30	**End**									

Date	Time	AF 11	AF 12	AF 13	AF 14	AF 15
9/30/99	8:30	**Opening Briefing**				
	9:00	A				
	9:30	B				
	10:00	**Break**				
	10:30	C				
	11:00	D				
	11:30	E				
	12:00	**Lunch**				
	13:00	F				
	13:30	G				
	14:00	H				
	14:30	I				
	15:00	J				
	15:30	**Break**				
	16:00	**Caucus**				
	17:00	**End**				

Appendix C
Procedure Scripts

SAWS Human Factors Assessment

AIR TRAFFIC & FLIGHT SERVICE PROCEDURES

Instructions

These procedures have been designed to include all the functions you might use on a SAWS system as an operational air traffic controller or flight service specialist. Please go through these procedures slowly and take notes about your findings.

1. If the display is on, turn it off.
2. Turn the display on.
3. Adjust the brightness to a comfortable level.
4. Walk to the 75 degrees marker associated with this display.
5. Try to read each piece of data: wind speed, wind direction, wind gust, ambient temperature, dew point temperature, altimeter setting.
6. Walk to the 50 degrees marker associated with this display.
7. Try to read each piece of data: wind speed, wind direction, wind gust, ambient temperature, dew point temperature, altimeter setting.
8. Walk to the 0 degrees marker associated with this display.
9. Try to read each piece of data: wind speed, wind direction, wind gust, ambient temperature, dew point temperature, altimeter setting.
10. Complete the System Assessment Questionnaire.

SAWS Human Factors Assessment

AIRWAY FACILITIES PROCEDURES

Instructions

This procedure have been designed to include some important functions that you might use on a SAWS system as an airway facilities technician. We understand that this procedure is described only at a high level and that it represents only one of many procedures that might be used. This procedure was chosen because it allows you to interact and discuss many aspects of the system.

---

1. Situation: The controllers from the tower have called and have reported that the SAWS wind speed data seems to be slow by 20 knots. Their other equipment, observations, and pilot reports all suggest that the problem lies somewhere in the SAWS.

2. Examine the wind speed **sensor** and determine if the problem could lie there. Use whatever appropriate techniques are necessary to accomplish this, as specified by the candidate vendor. For the purpose of this procedure, we will pretend that no problems appear in the sensor.

3. Examine the **Sensor Unit** to determine if the problem could lie there. Use whatever appropriate techniques are necessary to accomplish this, as specified by the candidate vendor. For the purpose of this procedure, we will pretend that no problems appear in the Sensor Unit.

4. Examine the **Controls and Display Unit** to determine if the problem could lie there. Use whatever appropriate techniques are necessary to accomplish this, as specified by the candidate vendor. For the purpose of this procedure, we will pretend that the problem lies in the CDU.

5. Review and simulate any **repair or replacement** procedures to fix the problem in the CDU. Use whatever appropriate techniques are necessary to accomplish this, as specified by the candidate vendor. (However, please do not actually remove or replace equipment.)

6. **Verify** that the wind speed data is now being received and processed accurately. Use whatever appropriate techniques are necessary to accomplish this, as specified by the candidate vendor.

SAWS Human Factors Assessment

STATEMENT OF CONFIDENTIALITY AND INFORMED CONSENT

Engineering research psychologists from the NAS Human Factors Branch of the William J. Hughes Technical Center (ACT-530) maintain strict standards regarding participant confidentiality and informed consent in all our research. Our standards are based on the *Ethical Principles in the Conduct of Research with Human Participants* by the American Psychological Association. Our standards are structured around four main principles:

- **Your participation is voluntary.** You may withdraw from this assessment at any time without consequence. If you feel you must withdraw for whatever reason, please inform us immediately. In addition, the psychologists may terminate your participation if they feel this to be in your best interest.

- **Your responsibilities will be clear.** We will clearly explain what is expected of you during the assessment. We will answer all questions about the objectives of the assessment, the assessment procedure, and the data collection techniques. These responsibilities are outlined on the back of this sheet.

- **Your data will be anonymous.** Your responses will be identified by a code known only to you and the psychologists conducting the assessment. Your identity will be kept separate from the data you provide. To facilitate this, please do not write your name or any other identifying marks on the questionnaires. Please do not share your participant code with anyone other than the psychologists. Your name will not be associated with any data contained in any report or briefing.

- **Your data will be confidential.** The *raw* data collected in this assessment will become the property of ACT-530. The raw data will be analyzed by specialists from this organization and its contractor employees. The raw data will not be made available to other organizations without your permission. The *aggregate* data from this assessment will be presented in briefings and reports made by ACT-530 to various organizations in the Office of Air Traffic Systems Development (AUA) and elsewhere in the FAA. These data will take the form of averages, standard deviations, and other statistics.

We hope that by protecting your rights, we are encouraging you to be as accurate and honest in your responses as possible. Thank you for your participation!

Kenneth R. Allendoerfer, ACT-530
William J. Hughes Technical Center, Bldg. 28
Atlantic City International Airport, NJ 08405
kenneth.allendoerfer@tc.faa.gov

Nature and Purpose

The purpose of the assessment is to examine the human factors attributes of candidate SAWS systems. We are seeking your input to help the FAA select a SAWS system that meets your needs and is easy to use and maintain. As a participant in this assessment, you will observe and interact with candidate systems and will complete several questionnaires. Air traffic participants will assess each system twice: once in bright illumination (similar to the tower during the day) and once in dark illumination (similar to the TRACON or the tower at night). Flight service and airway facilities participants will assess each system once.

Experimental Procedures

During the assessment, you will observe and interact with each candidate system. Air traffic and flight service participants will read weather information from the system from three different angles and then will complete a questionnaire. Airway facilities personnel will conduct a diagnostic procedure and then will complete a questionnaire. After all assessments are complete, there will be a group caucus where you may given any additional feedback.

Discomforts and Risks

There are no special discomforts or risks associated with this assessment. You interact with the candidate systems in a manner very similar to how you would use this equipment in a field facility. The lamps used to create the bright illumination condition will not be brighter than the illumination typically found in air traffic control towers during daytime operations. By participating, you **do not** give up any legal rights or release any individual or institution from liability for negligence.

Benefits

You will receive no direct benefit from being a participant in this assessment. However, this assessment will provide input to the SAWS vendor selection. Your input will help the FAA select a SAWS system that supports the users' needs and that is easy to use and maintain. By providing your input, you are helping the FAA acquire a SAWS system that you and your colleagues around the country will use for years.

Participant's Responsibilities

It will be your responsibility to interact with the candidate SAWS equipment following a short script of activities that will be provided to you. These activities were selected to provide you with sufficient exposure to the system so that you can evaluate it. The activities are very similar to what you might do in the field, such as reading weather information from the display or running a diagnostic procedure. Once you have finished the script, you will complete a questionnaire asking you to judge the candidate system on a variety of human factors attributes. You will also participate in a group caucus after all the assessments are completed.

Thank you for your participation!

SAWS Human Factors Assessment

COMPARISON TO HUMAN FACTORS GUIDELINES

Date: _____

System Code: A B C D E F G H I J

HFDG = Wagner, et al. 1996

Cardosi = Cardosi & Murphy, 1995

ANSI = ANSI/HFS 1988

Guideline	Source	System Follows?
Data		
Characters and symbols can be read easily under all anticipated lighting conditions (e.g., from dim light to direct sunlight).	Cardosi (9.3.4, 9.6.1, 9.6.2, 7.2.8)	
The luminance of dynamic text and symbols are eight times that of the static background.	Cardosi (7.2.22) HFDG (7.2.4.6.3) ANSI (6.4)	
A symbol should be: (1) an analog of the object it represents, (2) in general use and well known to the users, or (3) based on established standards or conventional meanings.	HFDG (8.5.4.8.1)	
If special symbols, such as asterisks or arrows, are used, they shall be used consistently and with unique meanings throughout an application and related applications.	HFDG (8.5.4.8.2)	

Guideline	Source	System Follows?
Information is never blocked or obstructed by other information.	Cardosi (7.2.17)	
Alphanumeric codes should use either upper case letters or lower case letters consistently; they should not use mixed cases.	HFDG (8.5.4.2.2)	
Abnormal data are emphasized effectively so that it attracts the user's attention.	Cardosi (7.2.11)	
Display clutter is not a problem.	Cardosi (7.2.20)	
Text Characteristics		
The minimum height of displayed characters should be 1/200 of the viewing distance **[at 9 feet, this is .54 inches]**	HFDG (8.2.3.7) ANSI (6.14)	
The ratio of character height to width shall be: a. 1:0.7 to 1:0.9 for equally-spaced characters and lines of 80 or fewer characters **[with .54, this is .38 to .49 inches]**	HFDG (8.2.3.8) ANSI (6.15)	
Stroke width should be 10 to 12.5 percent of character height **[with .54 inches, this is .05 to .07 inches]**	HFDG (8.2.3.9) ANSI (6.18)	
Color		
When the meaning of the color is critical, color is used redundantly with another type of visual cue, such as shape, text or size.	Cardosi (7.2.12, 3.2.3) HFDG (8.5.4.5.3)	

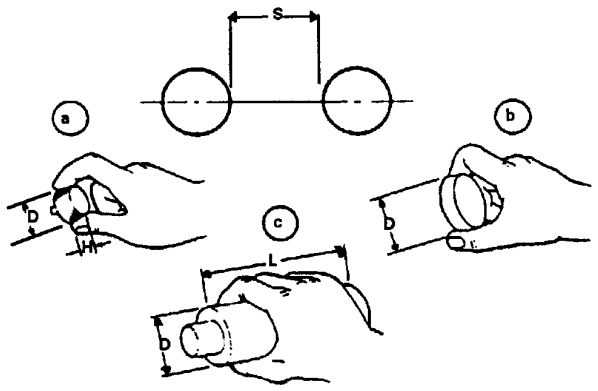
Guideline	Source	System Follows?
Colors shall be easily discriminable, and color shall be used conservatively and consistently, with each color representing only one category of displayed data.	HFDG (8.5.4.5.4) Cardosi (9.6.1)	
The controller will not need to identify more than five colors (i.e., to interpret the meaning of the color when it stands alone).	Cardosi (7.2.13, 3.2.4)	
Color coding shall conform to the following reserved meanings: a. Red shall indicate conditions such as "no-go," "error," "failure," or "malfunction." b. Flashing red shall be used only to indicate emergency conditions requiring immediate user action to avert personnel injury or equipment damage. c. Yellow shall indicate marginal conditions, alert users to situations where caution or rechecking is necessary, or notify users of an unexpected delay. d. Green shall indicate that a monitored process or unit of equipment is within tolerance, that a condition is satisfactory, or that it is all right to proceed with an operation or transaction. e. White shall indicate alternative functions or system conditions that do not have operability or safety implications. f. Blue shall be used only as an advisory color.	Cardosi (7.2.12) HFDG (8.5.4.5.1)	
Brighter or more saturated colors should be used to draw a user's attention to critical data.	HFDG (8.5.4.5.5)	
Labels		

Guideline	Source	System Follows?
Labels shall be unique, brief, and meaningful, and they shall be located prominently and consistently.	HFDG (8.5.6.6.2)	
Labels, terms, and abbreviations are used consistently across the system.	Cardosi (7.2.15) HFDG (8.5.2.1.1)	
The labels should be alphanumeric. If they are not complete words, labels should be abbreviations that are short enough (3 to 7 characters) or meaningful enough to be learned and remembered easily.	HFDG (8.5.2.2.2)	
Monitor		
According to the display monitor manufacturer's report, the display refreshes at a rate of 65 cycles (or more) per second so that the display does not appear to flicker.	Cardosi (7.2.6, 7.2.22, 3.1.6) HFDG (7.2.4.1.1) ANSI (6.11)	
According to the display monitor manufacturer's report, a displayed object moves no more than .0002 times the viewing distance in one second so that no display jitter can be detected. **[at 9 feet, this is .02 inches]**	Cardosi (7.2.22, 7.2.23) ANSI (9.11)	
Horizontal and vertical displacement of a symbol position relative to adjacent positions should not vary by more than 5% of the symbol box height. **[at .54 inches, this is .027]**	ANSI (6.9.1)	

Guideline	Source	System Follows?
Mechanical Controls		
Controls are clearly visible and easy to use under all anticipated lighting conditions (e.g., from dim light to direct sunlight).	Cardosi (9.3.4, 9.6.1, 9.6.3, 7.2.8)	
Mechanical controls are sized and spaced to support activation but to prevent accidental activation.	Cardosi (7.4.3)	
The surfaces of pushbuttons are rough or concave	Cardosi (7.4.3)	
Labeling of controls is consistent	Cardosi (7.4.3)	
The active and inactive states of pushbuttons are visually distinct.	Cardosi (7.4.3)	
Knob dimensions and separation shall not exceed those shown in Figure E-1.	HFDG (7.4.4.4.1)	
Continuous Thumbwheel dimensions and separation shall not exceed those shown in Figure E-2.	HFDG (7.4.4.6.1)	
Push Button dimensions and separation shall not exceed those shown in Figure E-3.	HFDG (7.4.4.8.1)	
Toggle Switch dimensions and separation shall not exceed those shown in Figure E-4.	HFDG (7.4.4.10.1)	
Rocker Switch dimensions and separation shall not exceed those shown in Figure E-5.	HFDG (7.4.4.12.1)	
Slide Switches dimensions and separation shall not exceed those shown in Figure E-6.	HFDG (7.4.4.13.1)	
Access and Maintenance		

Guideline	Source	System Follows?
If a maintainer must see what he or she is doing inside the opening, then either the opening shall be large enough and positioned so that the maintainer has the necessary view, or separate openings shall be provided for visual and physical access.	HFDG (6.4.2.1)	
An access opening shall be large enough to accommodate whatever combination of components, tools, body parts, clothing, and movements is required to perform the task (see Figure E-7).	HFDG (6.4.3.1)	
If a unit of equipment is designed to be lifted by a single person, its weight shall not exceed the value in Figure E-8 that is appropriate for the height to which it is to be lifted and the size of the unit as it affects the distance between the body and the grip. If a unit of equipment is designed to be lifted by two people, the weight lifted by either one of them shall not exceed the appropriate value given in Figure E-8 thus, if the weight of the unit is distributed uniformly, the maximum weight is twice that for a single person.	HFDG (6.2.2.1 & 6.2.2.7)	
If any hazard exists in servicing or maintaining a unit of equipment, the equipment shall have a warning label attached that describes the hazard.	HFDG (6.3.5.1.2)	
If there are critical instructions for the servicing or maintenance of a unit of equipment, and if these instructions are not likely to be available through other means, they shall be provided in a label on the equipment.	HFDG (6.3.5.1.4)	
Equipment labels shall be located so that they are visible and readable with the equipment in its installed position.	HFDG (6.3.5.2.1)	

Guideline	Source	System Follows?
It shall be clear to the maintainer how to open a cover, either through a property of the cover itself, such as its shape, or by the provision of instructions on or near the cover.	HFDG (6.5.1.1)	
Hinged and sliding covers shall be located so that when they are open, they do not interfere with access to the openings themselves, or to related controls, displays, test points, and the like.	HFDG (6.5.4.2)	
If a hazardous condition (such as a high voltage or moving parts) exists behind a cover or shield, that cover or shield shall have an interlock that disables the hazard when the cover or shield is removed or opened.	HFDG (6.5.9.1)	

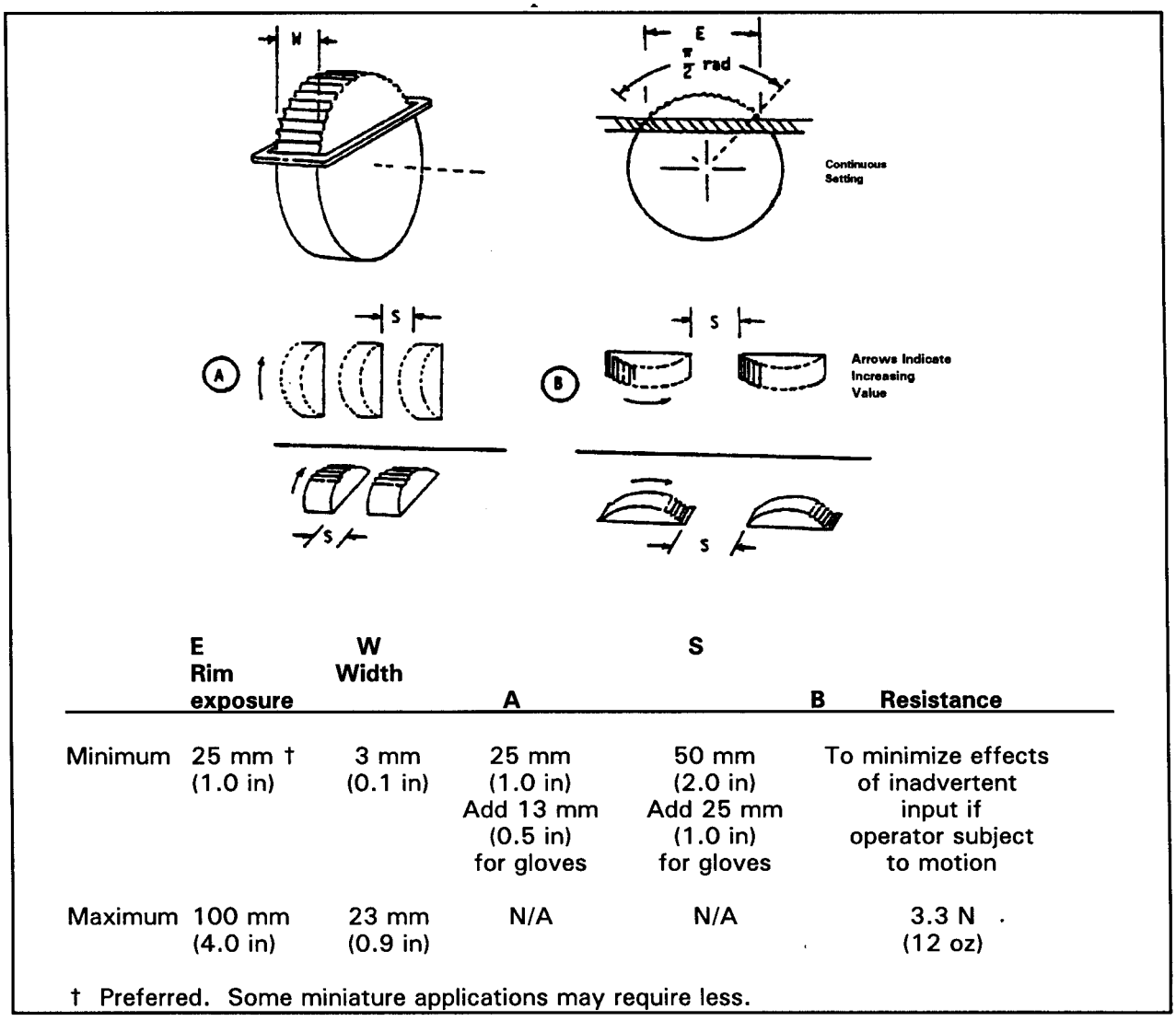


	a Fingertip grasp		b Thumb and finger encircled	c Palm grasp	
	H Height	D Diameter	D Diameter	D Diameter	L Length
Minimum	13 mm (0.5 in)	10 mm (0.4 in)	25 mm (1.0 in)	38 mm (1.5 in)	75 mm (3.0 in)
Maximum	25 mm (1.0 in)	100 mm (4.0 in)	75 mm (3.0 in)	75 mm (3.0 in)	

	Torque		Separation	
	†	‡	S One hand individually	S Two hands simultaneously
Minimum	--	--	25 mm (1 in)	50 mm (2 in)
Optimum	--	--	50 mm (2 in)	125 mm (5 in)
Maximum	32 mN*m (4.5 in*oz)	42 mN*m (6.0 in*oz)	--	--

† To and including 25 mm (1 in) diameter knobs
‡ Greater than 25 mm (1 in) diameter knobs

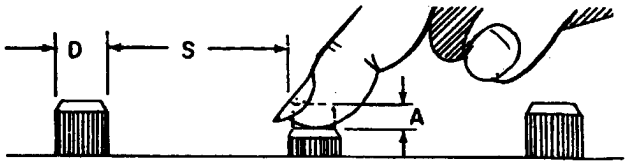
Figure E-1. Knob guidelines.



	E Rim exposure	W Width	S A	S B	Resistance
Minimum	25 mm † (1.0 in)	3 mm (0.1 in)	25 mm (1.0 in) Add 13 mm (0.5 in) for gloves	50 mm (2.0 in) Add 25 mm (1.0 in) for gloves	To minimize effects of inadvertent input if operator subject to motion
Maximum	100 mm (4.0 in)	23 mm (0.9 in)	N/A	N/A	3.3 N (12 oz)

† Preferred. Some miniature applications may require less.

Figure E-2. Continuous thumbwheel guidelines.



Dimensions

	Diameter D		Resistance		
	Fingertip	Thumb or palm	Single finger	Different fingers	Thumb or palm
Minimum	9.5 mm (0.375 in)	19 mm (0.75 in)	2.8 N (10 oz)	1.4 N (5 oz)	2.8 N (10 oz)
Maximum	25 mm (1 in)		11 N (40 oz)	5.6 N (20 oz)	23 N (80 0z)

Displacement A

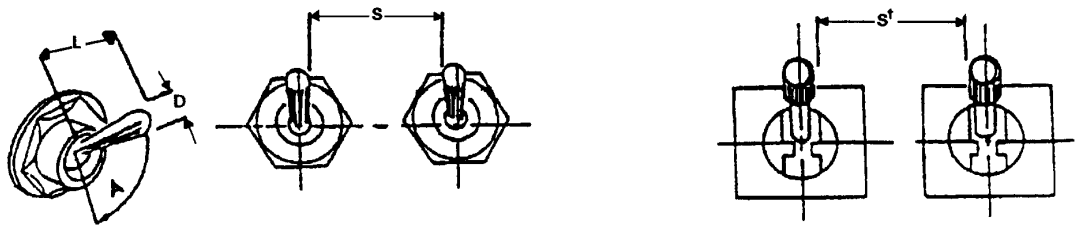
	Fingertip	Thumb or palm
Minimum	2 mm (0.08 in)	3 mm (0.125 in)
Maximum	6 mm (0.25 in)	38 mm (1.5 in)

Separation S

	Single finger	Single finger sequential	Different fingers	Thumb or palm
Minimum	13 mm (0.5 in)	6 mm (0.25 in)	6 mm (0.25 in)	25 mm (1 in)
Preferred	50 mm (2 in)	13 mm (0.5 in)	13 mm (0.5 in)	150 mm (6 in)

Note: These data are for barehand operation. For gloved hand operation, the minimum values should be suitably adjusted

Figure E-3. Push button guidelines.



	Dimensions			Resistance	
	L Arm length *	L Arm length **	D Control tip	Small switch	Large switch
Minimum	13 mm (0.5 in)	38 mm (1.5 in)	3 mm (0.13 in)	2.8 N (10 oz)	2.8 N (10 oz)
Maximum	50 mm (2 in)	50 mm (2 in)	25 mm (1 in)	4.5 N (16 oz)	11 N (40 oz)

Displacement between positions

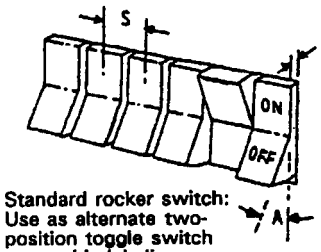
	A	
	2 position	3 position
Minimum	30°	17°
Maximum	80°	40°
Preferred	-	25°

Separation

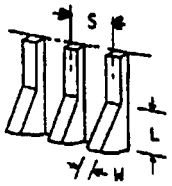
	S			
	Single finger operation †	Single finger sequential operation	Simultaneous operation by different fingers	
Minimum	19 mm (0.75 in)	25 mm (1 in)	13 mm (0.5 in)	16 mm (0.63 in)
Optimum	50 mm (2 in)	50 mm (2 in)	25 mm (1 in)	19 mm (0.75 in)

* Use by bare hand
** Use with heavy handwear
† Using a lever lock toggle switch

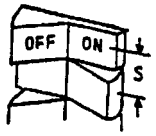
Figure E-4. Toggle switch guidelines

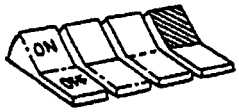


Standard rocker switch: Use as alternate two-position toggle switch to provide labeling surface, ease of color coding, and switch illumination.



Narrow width, especially desirable for tactile definition with gloves.



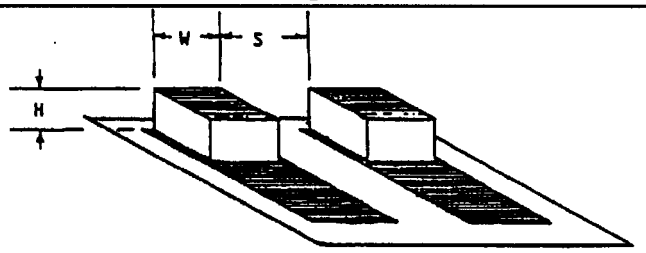


Alternate (contrast) color for on versus off to provide conspicuous cue of switch position. Illuminated "on" desirable as second feedback cue.

	Dimensions		Resistance
	W, width	L, length	
Minimum	6 mm (0.25 in)	13 mm (0.5 in)	2.8 N (10 oz)
Maximum			11 N (40 oz)

	Displacement		Separation (center-to-center)	
	H, height depressed	A, angle	S (Bare hand)	S (Gloved hand)
Minimum	3 mm (0.1 in)	30°	19 mm (0.75 in)	32 mm (1.25 in)

Figure E-5. Rocker switch guidelines

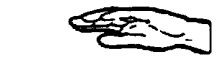


	Dimensions			Resistance	
	H Actuator height †	‡	W Actuator width	Small switch	Large switch
Minimum	6 mm (0.25 in)	13 mm (0.5 in)	6 mm (0.1 in)	2.8 N (10 oz)	2.8 N (10 oz)
Maximum	-	-	25 mm (1.0 in)	4.5 N (16 oz)	11 N (40 oz)

	S, separation		
	Single finger operation	Single finger sequential operation	Simultaneous operation by different fingers
Minimum	19 mm (0.75 in)	13 mm (0.5 in)	16 mm (0.6 in)
Optimum	50 mm (2.0 in)	25 mm (1.0 in)	19 mm (0.75 in)

† Use with bare
‡ Use with heavy handwear

Figure E-6. Slide switch guidelines



	Height mm (in)	Width mm (in)	Diameter mm (in)
Empty hand, to wrist			
Bare hand, flat	55 (2.25)	100 (4.0)	100 (4.0)
Bare hand, rolled	95 (3.75)	95 (3.75)	95 (3.75)
Glove or mitten	100 (4.0)	150 (6.0)	150 (6.0)
Arctic mitten	125 (5.0)	165 (6.5)	165 (6.5)
Clenched hand, to wrist			
Bare hand	5 (3.75)	125 (5.0)	125 (5.0)
Glove or mitten	115 (4.5)	150 (6.0)	150 (6.0)
Arctic mitten	180 (7.0)	215 (8.5)	215 (8.5)
Hand plus 25 mm object, to wrist			
Bare hand	95 (3.75)	95 (3.75)	95 (3.75)
Glove or mitten	150 (6.0)	150 (6.0)	150 (6.0)
Arctic mitten	180 (7.0)	180 (7.0)	180 (7.0)
Hand plus X mm object, to wrist			
Bare hand	X + 45 (1.75) clearance around object		
Glove or mitten	X + 65 (2.5) clearance around object		
Arctic mitten	X + 90 (3.5) clearance around object		
Arm to elbow			
Light clothing	100 (4.0)	115 (4.5)	115 (4.5)
Arctic clothing	180 (7.0)	180 (7.0)	180 (7.0)
With object	Same clearances as hand plus object		
Arm to shoulder			
Light clothing	125 (5.0)	125 (5.0)	125 (5.0)
Arctic clothing	215 (8.5)	215 (8.5)	215 (8.5)
With object	Same clearances as hand plus object		

Figure E-7. Minimum dimensions of openings designed for access by one hand or arm without visual access.

Height to	Distance between body and grip			
which lifted	**150 mm (6 in)**	**300 mm (12 in)**	**460 mm (18 in)**	**610 mm (24 in)**
.9 m (3 ft)	20.2 kg (44 lb)	13.3 kg (29.3 lb)	10.1 kg (22 lb)	6.6 kg (14.7 lb)
1.5 m (5 ft)	16.8 kg (37 lb)	11.2 kg (24.7 lb)	8.4 kg (18.5 lb)	5.6 kg (12.3 lb)

Figure E-8. Maximum weight limits for objects lifted by one person using both hands; data are for a male or female